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Publication date:
2015

[Link to publication in University of Groningen/UMCG research database](#)

Citation for published version (APA):

Paping, R. (2015). Measuring agricultural productivity during a century of population growth using farm accounts, production statistics and an income approach (Groningen 1762 – 1862). Paper presented at Eurasian Rural and Agricultural History Workshop, Groningen, Netherlands.

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Measuring agricultural productivity during a century of population growth using farm accounts, production statistics and an income approach (Groningen 1762 - 1862)¹

Richard Paping (University of Groningen)

Paper to be presented at the Eurasian Rural and Agricultural History Workshop (25-27 June 2015, Groningen)

Work in progress

1. Introduction

Until well into the nineteenth century agriculture was the main economic sector in most economies. Consumption consisted for a major part of necessities as food and other products (think of wool, linen, lamp oil etc.) that were directly or indirectly produced by agriculture. A rising per capita production in agriculture, offers either the opportunity of rising per capita food production and so in a rising standard-of-living, or releases people to produce – often more luxury – non-food products within industry and services, culminating also in an increase in standard-of-living. Starting in England in the last decades of the eighteenth century, but spreading out in an uneven speed elsewhere in Europe, the so-called ‘Industrial Revolution’ resulted in a rise in industrial labour productivity due to technological developments and increasing capital investments (preventing decreasing marginal returns of labour in industry). This process was accompanied by a shift in labour from agriculture to industry and services, and a shift of the growing population from countryside to city. From the end of the eighteenth century onwards population-growth in most Western-European countries accelerated to about 1% a year.

Without significant technological and organisational developments and major land reclamations, population growth – assuming it results in an equally rising labour input – might lead to Malthusian diminishing marginal returns to labour in agriculture and a falling agricultural labour productivity. The consequence of such a process would be a fall in food production and consumption per capita. This development would even be strengthened when part of the labour input shifts from agriculture to the non-food sectors industry and services as actually happened in the nineteenth century. While production per head of the population outside agriculture was rising rapidly due to relatively rising labour input and growing labour productivity, agricultural production per head of the population might have fallen relatively due to diminishing labour input and stagnating or falling labour productivity.

¹ This paper is largely based on calculations made and views developed in two older publications: my thesis on the standard of living of farmers, labourers and middle class in the Groningen clay region 1770-1860 (Paping 1995a) and a completely independent paper on agricultural production in Groningen using farm accounts 1762-1862 (Paping 1995b). The results of both have never been systematically presented in English.

Findings on the development of the standard-of-living show that on the one hand major measures like conscription heights, food-intake per capita and real wages measured in food prices did not develop favourably or even deteriorated in the first five-six decades of the nineteenth century or even longer. On the other hand real per capita national income figures show consistent rises in the same period (Maddison). These apparently contradictory developments can be explained by a move of consumption from food to industrial products. As food became increasingly expensive (due to the lagging behind of supply) compared to industrial products the negative effect of price elasticity on food consumption might have been stronger than the positive effect of income elasticity – at least for the lower classes – resulting in a fall in per capita food consumption. For industrial products the positive price elasticity (due to relatively falling industrial prices) and income elasticity moved in tandem, creating the huge consumer demand able to absorb the rapidly increasing industrial production both due to rising labour productivity and a rising relative labour input in this period.

In the previous exposé it was suggested that agricultural labour productivity presumably stagnated or will have decreased during the first half of the nineteenth century, a process that already might have started in the last decades of the eighteenth century. In this paper I want to test if such a decrease was really the case in a specific part in the north of the Netherlands, the Groningen clay region. Regarding certain aspects as population growth, the Netherlands really fit very well into the general picture. However, it can be doubted if an important shift from agriculture to industry and services took place in the Dutch economy as well. Until 1850 the Netherlands – being already extremely heavy urbanised in the seventeenth century – experienced a quite extensive de-urbanisation. Between 1790 and 1850 the share of people living in towns with medieval and early-modern legal city-rights (comprising nearly all major urban centres) fell from 41% to 37% (Paping 2014). The case of the Groningen clay region fit also in this development, showing a significantly higher population-growth than the nearby city of Groningen (see table 1).

Main question in this paper is: how did the agricultural productivity in the Groningen clay area develop between 1760 and 1860, and what were the consequences for the development of real incomes and the standard of living in the region?

Unfortunately, we do not have a lot of reliable figures on the development of Dutch agricultural production, mainly due to lack of sources. The figures we do have, usually not go back further than 1812, when during the French regime a lot of statistics have been collected of diverging quality and content (Van Zanden 1985). Only from 1817 onwards we have reliable statistics concerning the harvest of arable products. In this paper I will present, next to production estimates based on official statistics, also production estimates based on private farm accounts from 1762 onwards, and agrarian income estimates based on the development of agricultural wages and land prices from 1770 onwards until 1860. From about 1860 onwards there is not much doubt that Dutch agricultural production per capita was rising, and both real incomes and biological living-standards were increasing.

2. Background Groningen

This paper is mainly restricted to the Groningen clay region, a fertile part of the north of the Netherlands, characterized by a capitalistic market-oriented agriculture already at least from the sixteenth century onwards. The Groningen clay region comprises more than half of the province of Groningen. The rest of the province consisted of the capital of Groningen and the peat and sandy districts in the southwest and the southeast of the province. The Groningen clay region contained numerous small and large villages, but only one small city (Appingedam) and one more or less urbanized village (Winschoten), both with a population of less than 2,000. The occupational structure of the Groningen clay region was nevertheless very diversified, or with a better word specialised, with slightly more than 40% of the heads of households finding an occupation outside agriculture, taking also into account Appingedam and Winschoten. In most of the other - rural - municipalities between a quarter and sometimes more than a third was active as artisan, miller, merchant, inn-keeper, shipper, reverend, school master, physician and so on. Nonetheless, agriculture was the true engine of the economy, and most of the other activities were indirectly connected to the agriculture or otherwise were delivering general services to people active in agriculture mainly. This system made it possible that agrarians could usually totally concentrate on agricultural production. Consequently, agriculture was the only economic sector in the region producing substantial amounts of export goods directly or indirectly through oats, oil and flour (Paping 1995a).

Table 1: Estimated population, 1770-1860.

| | Groningen clay region | City of Groningen | Province of Groningen | The Netherlands | United Kingdom |
|--------------------|-----------------------|-------------------|-----------------------|-----------------|----------------|
| 1770 | 47,000 | 24,000 | 113,000 | 2,000,000 | 6,500,000 |
| 1809 | 58,000 | 26,000 | 131,000 | 2,200,000 | 8,600,000 |
| 1830 | 71,000 | 30,000 | 158,000 | 2,600,000 | 11,800,000 |
| 1860 | 93,000 | 36,000 | 205,000 | 3,400,000 | 18,000,000 |
| Increase 1770-1860 | 98% | 50% | 81% | 70% | 177% |

Sources: Paping (1995a); Paping (2004); Rough estimates from Wrigley and Schofield (1981) 208-209.

Considering the economic sectors, the occupational structure did not change much in the period 1760-1860, notwithstanding a doubling of the population. However, within agriculture enormous changes took place as the amount of farms did not increase a lot, resulting in a huge

rise in the group of (usually completely landless) farm labourers (so-called proletarianisation). Around 1760, some quarter of the economically active heads of household were labourers, to increase to 40.4% in 1860, while the share of farmers fell from a little less than a third to 16.4% in 1860. Small-scale farming (using less than 5 hectare) was very uncommon in the Groningen clay region, and the ordinary farm-size was between 10 and 50 hectare (Paping 1995a).

From the end of the eighteenth century a process of intensification in agriculture took off, due to an increasing input of labour. As already in the sixteenth century most of the Groningen clay region was cultivated (except for some small pieces of peat land within the region), the amount of hectares in production could nearly only increase due to reclamation of land on the water (the sea or river-deltas) from 100,000 hectares around 1770 to 110,000 around 1860 (Paping, 1995a, p. 353-354). At the same time, the higher labour input made an increase in the share of arable land possible from 42% in 1807 to 70% in 1862 (Priester 1991), while this share seem to have been even lower around 1770.

During the first half of the nineteenth century, the amount of fallow was reduced (instead clover as fodder for the cattle was sowed, improving also the quality of the land) and also pastures were changed into arable fields. Especially, crop rotation became popular, a few years of pasture alternated with six-seven years of crop rotation. Cultivation into rows made weeding much more important, demanding a lot of (female) work in spring. By using more labour, it was in this way possible to increase the amount of arable production, without diminishing the amount of livestock (needed for manure for the arable fields), though this also meant that an increasing part of the grain harvest had to be used as fodder for the animals. Next to this, the improvement in water management that took place made it possible to increase the quality of parts of the land that had been so wet they could only be used as relatively unproductive pasture lands, but now were cultivated with grain.

Changing to labour intensive production methods was from the 1780s onwards attractive as the price of agricultural products was increasing more rapidly than the costs of labour. Intensification was mainly possible within arable agricultural production, moving the orientation of the Groningen agriculture increasingly towards producing grain and oil seeds. Interestingly, exactly in the period 1818-1828 characterized by rising real agricultural wages the share of arable land did not increase (Priester 1991).

3. Method: Measuring agricultural production 1817-1862 using official statistics

Annual provincial statistics are available for the size of the cultivated land and the production per hectare for grain (rye, wheat, barley and oats), oil-seed (“koolzaad”), peas, beans, potatoes and other arable products from 1817 onwards. Priester (1991) calculated the total gross real arable production in prices of 1861/70, and also gives information on the share of the Groningen clay region in the provincial production in the period 1817/21, 1831/35 and

1860/64.² An interpolation of these shares has been used to calculate annual figures for the Groningen clay region. The share of the arable production used as fodder and sowing-seed increased according to Priester from 15% in 1815 to 24% in 1862. We assumed this share to be increasing at a constant rate during the whole period. The result was a series of the annual gross arable production in the Groningen clay region.

For the livestock production we only took the production of cattle meat and butter into account. For several years the amount of cows is known for all the municipalities in the Groningen clay region, for other years these figures could be extrapolated using provincial figures. However, due to lack of information the figures for 1831-1839 and 1845-1849 were linear interpolations. About 95% of the cows above two year will have been potentially lactating, but from these only 80% will really have been lactating in accordance with the estimates of Priester (1991). According to him 53.7% of the potentially lactating cows were exported in 1815, a share that fell to 52.5% in 1862. The amount of meat produced annually was estimated taking into account figures on the average weight of cows slaughtered by institutions in the city of Groningen. Priester (1991) also suggests a considerable rise in the production of butter per cow (assuming that all the milk was transformed into butter) from 62,3 kilo in 1815 to 82 kilo in 1862, again we assumed a gradual increase (see also Paping 1995a, p. 337-338, for a more detailed description of the estimation procedure and the sources used).

As we will see, Priester seriously overestimated the export of cows and so the production of meat if we look at the number of cows sold in the farm accounts. Nevertheless we used these high estimates for livestock, to compensate for the exclusion in the estimate of the production of pig meat, poultry (eggs and meat), sheep (wool and meat) and horses to be used outside agriculture, or outside the Groningen clay region.

The statistical series resulting in nominal production figures that have been deflated to get real figures using general price series on arable production (60%) and livestock production (40%) developed in my thesis (Paping 1995a, p. 392-394) with a base period 1831/1850 is 100.

4. Method: Measuring agricultural production 1762-1862 using farm accounts

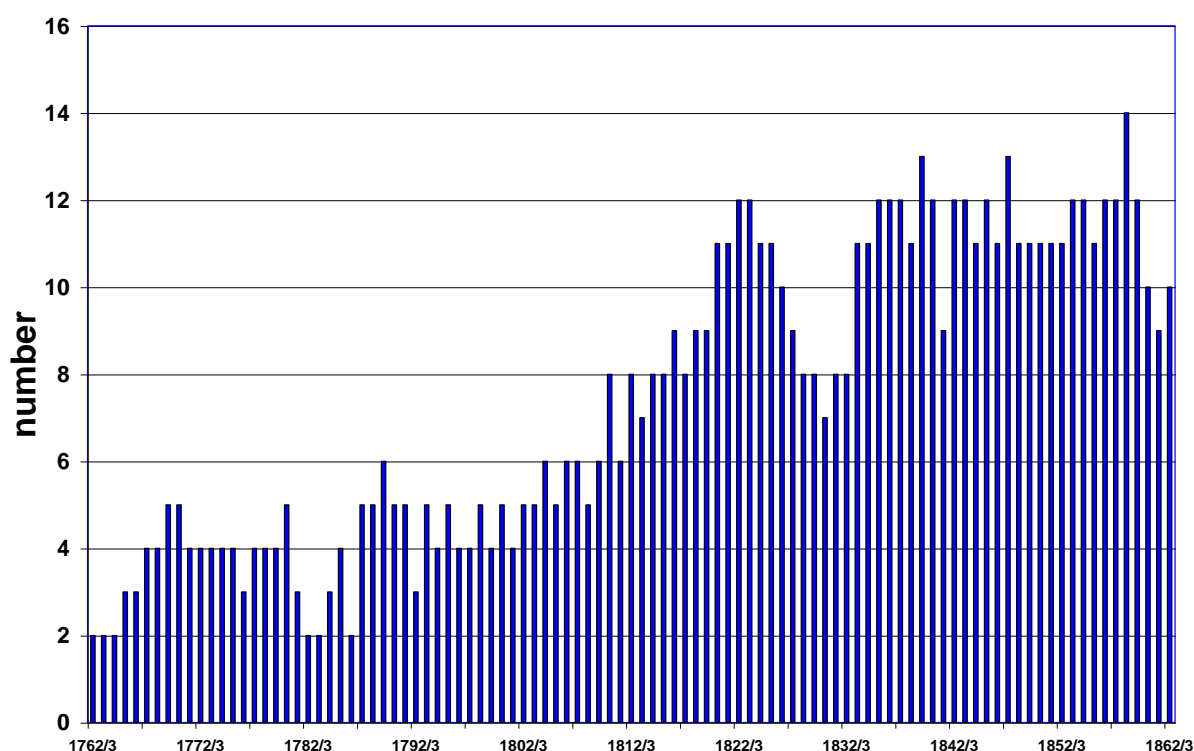
Some forty farm accounts for the Groningen clay area have been assembled, that offer information on the selling of agricultural products by specific farmers over a certain amount of years during the period 1762-1862. The information on the amount sold and the prices of every agricultural products was assembled for each harvest year possible. Most of the information was complete, however, for some smaller obvious omissions corrections have been made. The largest problem was that a few farmers in the eastern part of the clay region (Oldambt) did not write down information on the selling of livestock products. Livestock

² Priester (1991) does not include Winschoten and Scheemda in the clay region, but here a correction has been made for that.

production of these farmers has been estimated using eastern farms that were complete in the same year.

For every farm the size was know. In the cadastral archives the tax value of these specific farms in 1832 could be found (this tax only starts in 1832, replacing a more old-fashioned land tax). The government spend a lot of effort in the years before 1832 to establish the earning capacity of each piece of land in the Netherlands (Kint 1989), so the differences in tax value between seem farms seem meaningful. For eighteenth century farm accounts, I looked also at the average value of the land per hectare in 1832. Sometimes it was hard to establish if the size of the farm had not changed, but usually the information on the farm-size made it possible to address this problem. Sometimes parts of the land were rented out, but that was usually mentioned in the farm accounts. All farm-sizes were transformed into standard-hectares, taking into account that according to the cadastre the average taxable revenue per hectare in the Groningen clay region was 30.76 guilders in 1832. Interestingly, this is about a third lower than our estimates of the production value, although it has to be taken into account that the cadastre estimated the net revenue, also subtracting for instance taxes and costs of dike maintenance.

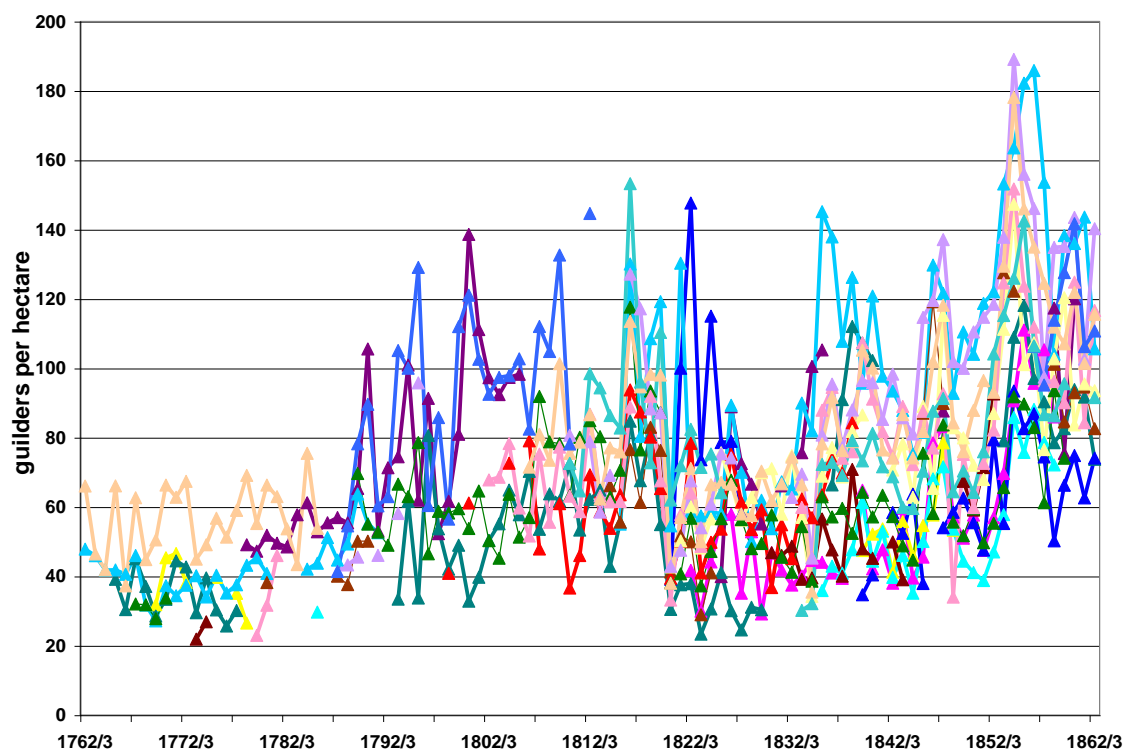
Graph 1: Number of farms in the farm account sample



By dividing the value in money of sales of each farm by the amount of standard-hectares we get for every year an estimate of the value of sold products per hectare. The number of farms in the sample differ from two to thirteen. From 1762/3 to 1766/7 and from 1781/2 to 1786/7 the sample is very small with only two to three farms. For the other years until 1812 usually

information for four to six farms is available. From 1812/13 onwards the sample definitely becomes larger with usually at least eight farms, and after 1832 often above ten farms per year (see Graph 1). Graph 2 makes clear that the annual individual figures show a large spread, although there are also some similarities in the movements of the nominal values.

Graph 2: Nominal production per hectare for Groningen farms 1762/3 - 1862/3



Both a weighted and a not-weighted series of average agricultural production per hectare have been constructed at first. For the period before 1815 the difference between the two was quite small as the farms have all a quite comparable size. However after 1815 on the one hand there were some relatively small farms, but there was also a very good series on the sales of the largest farm of the Groningen countryside of more than 200 hectares (Groot-Zeewijk). Average sales per hectare on this exceptional farm, being owned and lead by the very prominent farmer Geert Cornelis Reinders (who also became a member of the Dutch parliament) were in most years relatively very large, and so had a very positive effect on the weighted series.

The nominal series on the value of the sales per hectare has been deflated by a (Laspeyres) price index based nearly completely on the prices reported in the farm accounts. The value of the weights was established using the information on the sales in the farm accounts in the period 1831/1850 (again not weighted for farm-size), taking into account the difference between arable and livestock production.

Table 2: Weights of different price-index numbers (percentages): 1831/1850=100

| | Price-index farm accounts | Price-index statistics |
|-----------------------|---------------------------|------------------------|
| Beans and peas | 2.70 | 4.06 |
| Oats | 14.79 | 13.70 |
| Oil-seed ("koolzaad") | 20.23 | 7.64 |
| Wheat | 8.61 | 4.96 |
| Barley | 21.52 | 10.67 |
| Rye | 5.40 | 9.13 |
| Potatoes | - | 9.84 |
| Pigs | 3.18 | 7.46 |
| Cows | 16.25 | 17.91 |
| Butter | 5.55 | 8.47 |
| Milk and eggs | - | 6.16 |
| Wool | 1.77 | - |

Interestingly, table 2 shows some important differences between the price-index numbers, and accordingly between the production structure suggested by the statistics and that shown by the farm accounts. Livestock production had a much higher weight (40% compared to 27%) according to statistical estimates mainly based on Priester (1991). Only very partly this is due to his very high estimate of the export and slaughtering of cows (32,500 in 1815 and 38,600 in 1862 in the whole province). If the average amount of cows sold per hectare according to the farm accounts is used, taking into account the cows eaten within the farms, then total provincial production of cattle can be estimated to have been 24,000 in 1813/1822 and 27,000 in 1853/1862, considerably lower than the estimates of Priester, but still much higher than comparable estimates of Van Zanden (1985): 15,000 and 16,000.

Also within arable production there are some interesting differences. Oil-seed was an extremely important source of revenue in the farm accounts, as was wheat and barley. The sales of rye and beans and peas were much more limited, suggesting perhaps that a considerable part of this production was consumed within the farmstead by animals and humans. However, these differences also stress the problem that the sample of farm accounts might not have been completely representative, with relatively a lot of farms on the coast and in the east, where growing oil-seed was much more important than in the interior. But it also has to be remarked that oil-seed was the one product that could not be used in any way at the farm, so everything really had to be sold. The high sales of barley, that just as easily could be used as fodder as in that respect more remarkable.

This last point brings us to mention a very important conceptual difference between the statistical and farm account series, as they do not measure the same thing. In both cases the starting point is the gross production on the farm. For the statistical series we estimated the amount of sowing-seed and fodder, that is of course automatically excluded in farm account series. In the farm account series, however, also the other auto-consumption of the farmer and

his family is deducted from the gross production value, while it is included in the statistical series. A small difference will be the selling of products to be used as inputs on other farms that is included in the farm account series. Clearly, this happened only to a very limited extent according to the farm accounts. Mainly it concerned the sale of sowing-seed, horses and piglets. Both series neglect less important products, the statistical series in a rather systematic way, the farm account series because not every product was always mentioned in sources (think in both cases of fruit and vegetables).

5. Method: Measuring agricultural income 1770-1860

Basic idea of this measuring method is to divide the total income in labour income, capital income (including income from land) and profit income. All three sources of income can be estimated separately for each year in nominal terms. The weakest part of such an estimate is profit income, as it can only be estimated as a rest category comparing the annual value of agricultural production according to statistics with the total annual labour and capital income as is done in Paping 1995a (p. 359-362). Agricultural profits were shown to be highly depending on the price level and the change in prices relative to the previous year ($r^2 = 0,61$ for the period 1817-1860). This makes it possible to use the estimated regression line to also estimate the profit in the years before 1817. However, if profit income is measured in this way, it is not independent of the estimate of the production value. So in this paper we only look at the labour and the capital income. Consequently, the agricultural income estimates will be considerable lower than the agricultural production estimates, as will become clear when presenting the results.

Labour income is estimated by multiplying the estimated number of people occupied in agriculture with the amount of working days and the daily wage. For four different categories of labour annual estimates of the wage level have been constructed for the period 1770-1860, mostly by combining a wide range of evidence from farm accounts, official statistics and fragmentary sources (see: Paping 1995b, for the details).

- live-in female farm servants: annual wages (next to this they receive board and lodging).
- live-in male farm hands: annual wages (next to this they receive board and lodging).
- adult female farm labourers not living on the farm (usually married): daily wages (with no extra emoluments).
- adult male farm labourers not living on the farm (usually married): two series of daily wages (one without and one with getting the daily food supplied on the farm).

The value of board and lodging was estimated using a fixed amount of goods during the whole period (Paping, 1995, p. 404-406). It has to be remarked, that due to this procedure, this part of the labour income has a stabilizing effect on the general income. The value of the food received by farm labourers living elsewhere was estimated as 1/400 of the annual value of board of lodging of the live-in servants. The average wage of labourers was estimated as the average of the two separate series of wages.

The assumption has been made that the daily labour income of sons and daughters of farms was comparable with that of the live-in servants, while the daily labour income of farmers and farmers wives is comparable with that of farm labourers. The labour of farmer's sons and farm hands on the one hand, and farmer's daughters and farm maids were close substitutes (see for female labour also Van Nederveen Meerkerk and Paping 2014). So taking into account a perfectly working labour market their enumeration will have been equal, although for the farmer and his family in practise usually no wage was paid (in some cases older children received a wage on the farm in this highly capitalistic region).

The size of each working category over the whole period had been estimated using multiple statistics and censuses who were available for some years for some categories. In-between years were estimated using interpolation (Paping, 1995, p. 318, 321-330, taking also into account the annual population development of the Groningen clay region. Also taken was taken into account that some of the labourers also were active outside agriculture during some parts of the year, and increasingly so around 1850 (digging clay for stone factories, helping in the building industry, pulling ships and so on). Also a small part of the labour of those males working outside agriculture was attributed to agriculture, because some of the artisans and merchants had plots of land. However, the diminishing of this agricultural work by people mainly occupied in services and industry in the first half of the nineteenth century as is shown by them using less small agricultural plots of land, was also taken into account.

Table 2: Educated guesses of average labour input for each occupational category (days per year), 1770-1860

| | 1770 | 1790 | 1820 | 1822/28 | 1840 | 1860 |
|-----------------------------|------|------|------|---------|------|------|
| Farmers and farmers sons | 270 | 270 | 270 | 270 | 270 | 250 |
| Farmers wives and daughters | 200 | 200 | 200 | 200 | 190 | 150 |
| Live-in personnel | 285 | 285 | 285 | 285 | 285 | 285 |
| Male farm labourers | 275 | 275 | 275 | 225 | 237 | 260 |
| Female farm labourers | 75 | 80 | 125 | 100 | 115 | 140 |

Source: Paping (1995a) 332-333.

To measure the labour input precisely information on the amount of working days is needed also. Very exact statistical information, however, is not available. The standard working year has been set at 300 working days. From the 365-366 days a year, 52-53 Sundays should be subtracted, also according to the farm accounts people did not work during Christmas (25-26 December), New Year's day, and Easter, though other holidays seem to have been absent. For live-in servants we have information on the annual pay so this is not a problem, nevertheless 5% has been deducted for being ill and other reasons for not being active. The numerous surviving farm accounts offering contracts of live-in servants (Paping 2005) make clear that indeed for long stays of illness some of the wage was deducted, and sometimes servants on an annual contract were dismissed, taking it some time to hire a new one instead.

Capital income is estimated assuming a perfectly working capital market. Inventories of remarrying farmers make clear that farms, livestock and farm equipment were to a

considerable extent financed through loans. In 1770/76 average gross wealth in a sample of inventories of farmers was 3,563 guilders, financed for 39% by loans, in 1805/11 average gross wealth had increased enormously to 14,438 guilders, financed for 38% externally. In the period between the share of loans was even higher, sometimes even above 50% (Paping 1995a, p. 199). Taking this into account the market-interest rate on private loans (calculated through a sample of 50 contracts each year) must be a perfect indicator for the earnings on capital (also compare the recent arguments of Piketty). Farmers really had to use part of their earnings to pay this market interest rate because of their frequent and high debts.

The value of total capital invested in agriculture was estimated by multiplying the number of hectares with the price of land on the market. As there was a flourishing market for farms the archives provide plenty of material, for most of the years prices (including the farm buildings) of between 700 and 1500 hectares have been taken into account, to correct somewhat for differences in land quality the average cadastral municipal tax rate has been used. A complicating aspect was the very specific way the property of land was organised in the province of Groningen. During the second half of the eighteenth century most land owners (mainly nobles, patricians, well-to-do urban citizen and countrymen, rural and urban institutions) concluded contracts that made the land rents fixed eternally, giving the right to the land user to deal with the land anyway he/she liked, with the near only obligation to pay the annual fixed rent. Actually, these contracts only legalized a situation that already existed for some decades. Consequently, with the rising land prices the true value of land was not in owning the land, but in having the right to use it (a so-called “beklemming”) and in the buildings. These rights to use the land prices (nearly always connected to a farmstead) were found mostly in the sales contracts, the value of owning land that was rented out on fixed terms was estimated using far less contracts (a five-year moving average was used). Not very surprising this ownership right developed quite comparably with the general market interest rate. It became relatively less and less important by 1800 because of the enormous increase in the value of land.

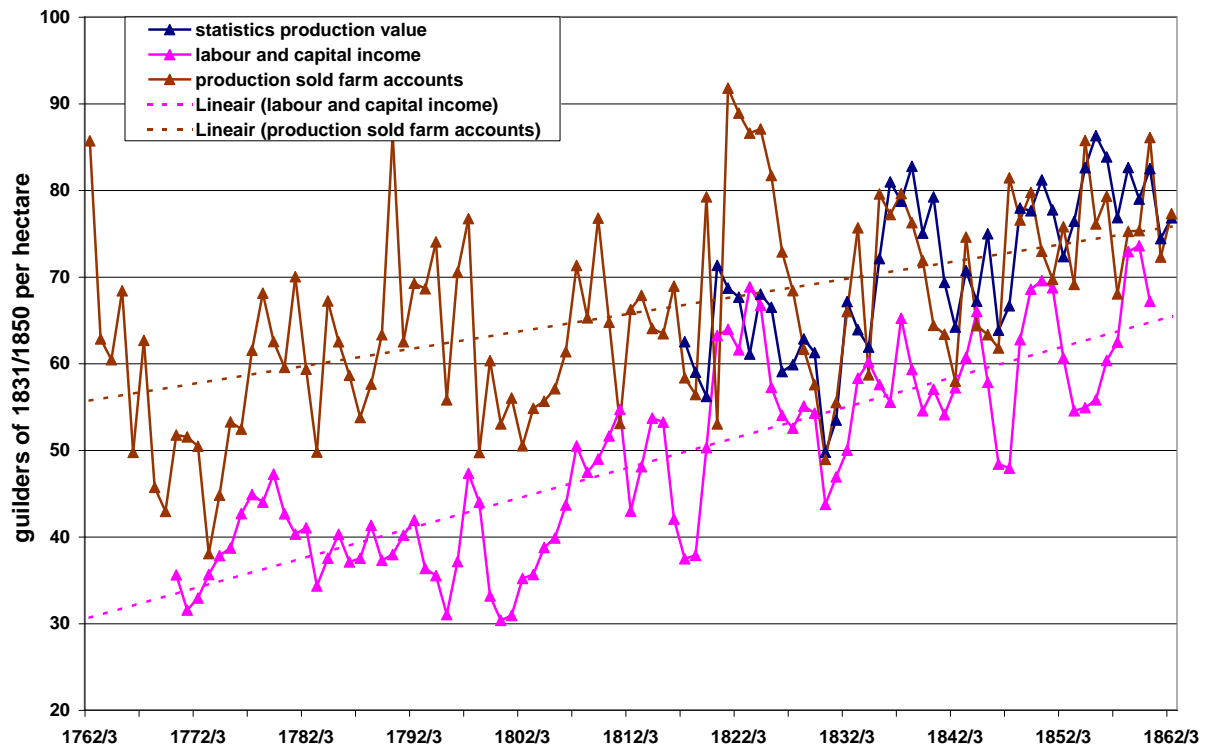
The value of agricultural equipment and of the livestock on the farm was estimated using statistics on the amount of animals in the Groningen clay region (cattle, horses and sheep) and information from inventories (value per hectare). Equipment and cattle only comprised some 10-20% of the value of the capital invested in agriculture. The main wealth was in the (right to use the) land and to a lesser extent in the farm buildings.

6. Results: agricultural productivity per hectare

In general the real agricultural production per year was characterized by huge fluctuations from one year to the other in the period 1762-1862 as graph 3 shows. Bad periods around for instance 1770, 1800 and 1830 with a low production, alternated with periods with significantly better harvests, for instance at the end of the eighteenth century and in the fifties

of the nineteenth century. There was a very great concordance between the statistical series on the production value and the farm account series from 1828 onwards (1827-1862: $r^2=0,56$)³.

Graph 3: Real agricultural production per hectare



However, between 1819 and 1827 there is no relation at all between the two series. In 1819 statistics show a diminishing of the agricultural productivity, whereas 8 of the 9 farm accounts show a considerable increase. In 1820, on the other hand the statistics show a real increase in productivity, however in the 9 farm accounts available the productivity fell by at least 25% in the same year. In 1821 the statistics show a fall in agricultural productivity, whereas all 11 farm accounts report considerable increases in agricultural productivity. In conclusion, the farm accounts in the period show a very consistent pattern of productivity development, a finding that cast serious doubts on the quality of the government statistics before 1827 which results differ so highly from the farm accounts in this period. We know that the government statistics on the agricultural production in 1817 were constructed using municipal figures (presumably supplied by the majors), and the same is certainly the case from 1832 onwards, as large tables with the municipal figures have survived in the archives. Perhaps a less thorough way of data-collection has been used in the period in-between.

Interesting is also the difference in level between the agricultural labour and capital income per hectare and the productivity according to the farm accounts. As profit income is not taken

³ Restricting ourselves to the arable production only the r^2 is even 0.73 between the two series.

into account we already were expecting the first to be considerably lower beforehand. However, the difference between 1775 and 1818 is nearly every year extremely high. This is of course a period of increasing agricultural prices, offering the farmers large opportunities to make huge profits, and a period in which the economic welfare of the farmers increased enormously. Nevertheless, these high profits cannot be the whole explanation of the difference. Are the farm accounts overestimating the agricultural productivity somewhat in this period, taken also into account that the sample is fairly small before 1812? Or is the estimate of capital and labour income simply far too low for this period? However, taking into account the high quality of the wage, interest and land prices series used for this period, there does not seem to be much room for the last proposition. In conclusion, in the rest of our analysis, we have to be aware of the major differences in the results of these two measuring methods.

Table 3: estimated annual trend growth rate of real agricultural productivity per hectare using different indicators.

| | 1770-1860 | 1817-1862 |
|---------------------------|-----------|-----------|
| Production statistics | n.a. | +0.68% |
| Farm accounts series | +0.36% | +0.24% |
| Labour and capital income | +0.71% | +0,52% |

This difference already clearly shows up in Table 3 showing the annual growth rate according to the trend (calculated using OLS assuming a constant growth rate)⁴. All three series show a significant - though diverging - rise in production per hectare in the period under study. Presumably this increasing land productivity was the effect of the continuous process of labour intensification that was going on in this period of consistent population growth of nearly 1% since the middle of the 1780s. Taking into account that the amount of land increased by only 10% (or nearly 0.1% annually), however, the magnitude of the increase in land productivity was rather disappointing, suggesting that there was no significant total factor productivity growth in this period.

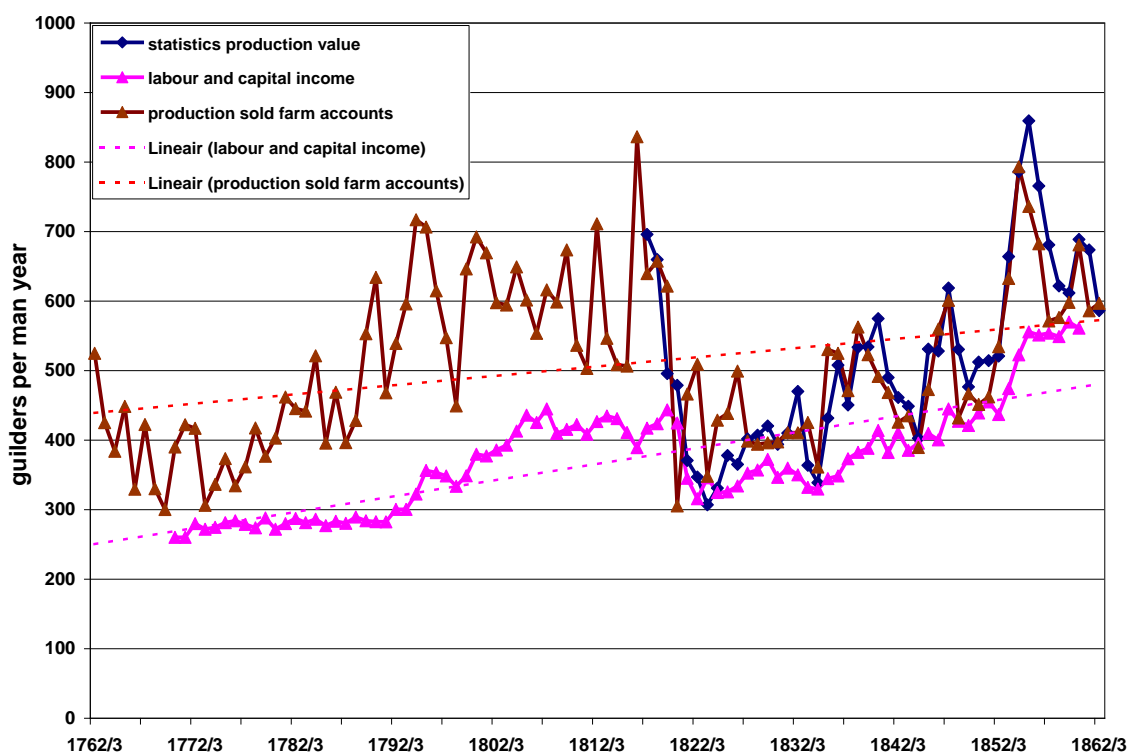
Rather surprisingly, the growth-rates for the whole period 1770-1860 were higher than for the last period 1817-1862. An explanation might be that productivity growth was still easier to reach in first instance before 1817, though it became increasingly more difficult to deploy extra labour in agriculture efficiently when the population growth continued. An argument that again suggests that important productivity increasing technological developments were not introduced before 1860.

7. Results: agricultural productivity per man year

⁴ Note that this is different than the absolute trend-lines shown in the graph.

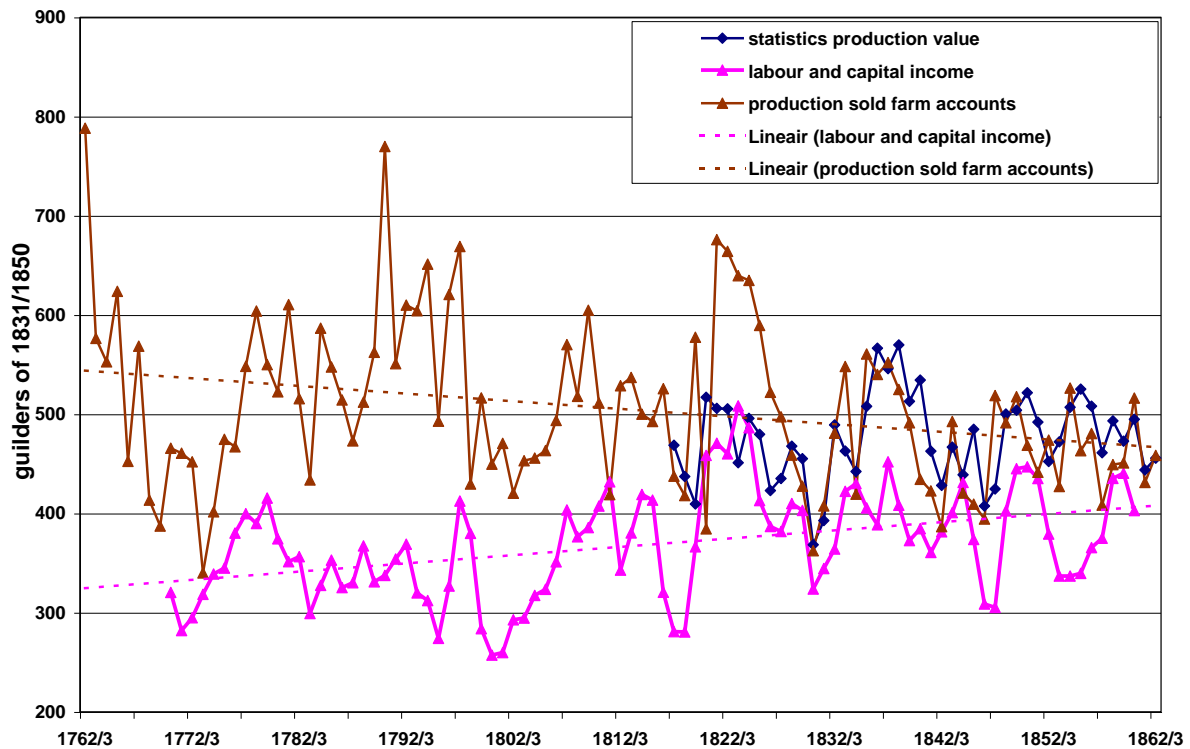
To calculate labour productivity per man hour, the estimated amount of annual labour input derived from the labour income estimates has been used. As female workers were usually enumerated at a level of 60% of the males in the Groningen clay region according to the collected wages, female labour got a weight of 60% of male labour. All three series were divided by the same data on annual labour input in agriculture. The data from farm accounts were multiplied by the total amount of hectares to get estimates of the total agricultural production in the Groningen clay region.

Graph 4: Nominal agricultural production per man year



In graph 4 figures on the nominal agricultural production per man year are presented. The very large difference between the total amount of labour and capital income between 1775 and 1818 already discussed is again striking. The development of nominal capital and labour income is rather smooth, as annual fluctuations in wages and land prices were fairly limited, compared to changes in harvest-yields. It must have been the profit income in which the effects of all the changes in harvests and agricultural prices show up, making profits very volatile during this period. Both the series for labour and capital income and the series based on the farm accounts show an upward trend, but these have more to do with price developments, as the movement of the agricultural price level was the most important determinant for the changes in the nominal values. From the 1770s until the first decades of the nineteenth century the prices increased. After an extremely large fall around 1820, they slowly began to increase again, a development going on until the 1850s.

Graph 5: Real agricultural production per man year



The two series result in diverging conclusions about the very long term development of the (real) agricultural labour productivity (graph 5). The farm account series suggest a slight fall for the whole period 1770-1860, that also shows up in the downward linear trend. However, the amount of real capital and labour income per man year in agriculture show a definite though very slow rise. A kind of difference we already came across when discussing production per hectare. However, both figures show that Malthus was not very far away, and that the rise in labour input lead to a stagnating or even falling labour productivity in the long run, because it was not accompanied by an equal rise in the amount of land. The growth trend of the labour input in the period 1770-1860 was slightly more than 0.6% annually, compared with a growth rate in the amount of land of about 0.1%.

Table 4: estimated annual trend growth of real agricultural productivity per man year using different indicators.

| | 1770-1860 | 1817-1862 |
|---------------------------|-----------|-----------|
| Production statistics | n.a. | +0.10% |
| Farm accounts series | -0.13% | -0.34% |
| Labour and capital income | +0.23% | -0.05% |

The finding of a stagnating labour productivity in agriculture during this period of rapid population growth is also clear as we consider the annual trend growth rates. Labour and capital income show a small structural rise, whereas the farm account suggest a slight

decrease in the long run. If we look at the period of definitely high population growth from 1817 onwards, calculated trend growth rates are diverging quite considerably. However, only the series on production statistics show an upward trend, what is caused by the very low production figures in the statistics in the period 1820-1827 compared to the farm accounts. It was exactly this period that we did cast doubt on the quality of these series. In this respect, it seems safe to conclude that from 1817 to 1860 agricultural labour productivity was decreasing in the long run, as would be expected when no significant structural productivity increasing technological development was taking place.

This is not to say that no innovations happened in the Groningen clay region. Actually, there were numerous innovations, usually directed towards using the abundance of labour supply more efficiently. We already mentioned sowing in rows, weeding, reducing the fallow by sowing clover, a list that can be appended by for instance the rise in clay digging in autumn and winter and spreading this still fertile clay over the land, better water drainage by putting clay pipes in the ground and so on (see Priester 1991 for an overview of the technological development). However, these innovations, though resulting in a higher production, were more directed towards using the abundant and cheap available labour force to increase the productivity of the scarce production factor land, than that they really increased the agricultural labour productivity.

8. Results: agricultural production per capita and the biological standard-of-living

On first sight it might seem peculiar to treat the development of agricultural production per inhabitant and the labour productivity separately, taken into account that we started remarking that the share of agriculture in the occupations of the heads of household did not change significantly in the period under research (paragraph 2). However, there was a substantial difference between the growth of population and of agricultural labour input in the Groningen clay region, and we will briefly summarize the causes for the relatively slow rise of agricultural labour input. These factors individually were not very substantial, but all together resulted in the agricultural labour input increasing in the period 1770-1860 with on average 0.61% whereas the population increased with 0.83%.

1. The shift in labour from farmer households to labourer households resulted in females becoming less occupied in agriculture. Married female labourers could only find work in agriculture during the summer half year between April and October (Van Nederveen Meerkerk and Paping 2014), whereas females living in a farmer household were active in agriculture the whole year through. That the amount of working days of female labourers was increasing during the first half of the nineteenth century (due to the introduction of weeding) only partly offset this development (see table 2).

2. The rising welfare of farmers from the end of the eighteenth century onwards (due to higher agricultural prices and their increasing property rights on the land) resulted that the farmer family put less effort in agricultural work. Around 1850, very rich farmers and their wives were said to only supervise the work, not doing much physical work themselves anymore, as

they used to do in the eighteenth century, also because they previously had far less hired labour at their disposal. Presumably also the effort of the grown-up farmer children diminished by 1850 (see table 2).

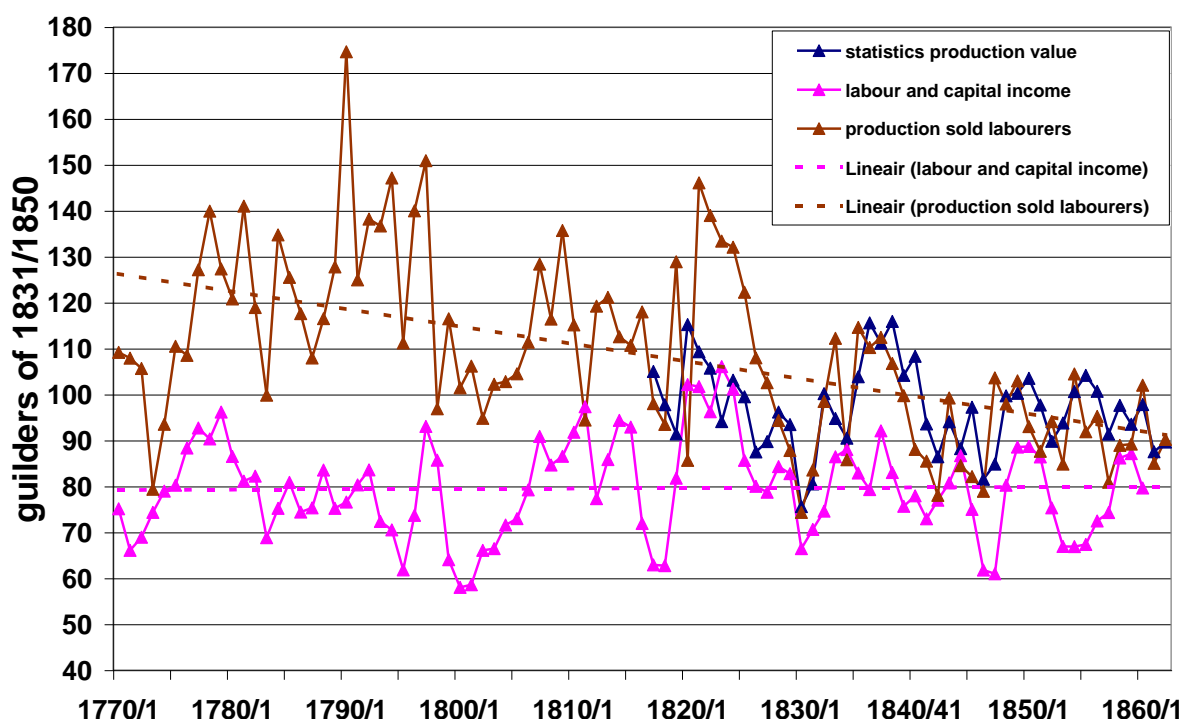
3. A diminishing share of the heads of households outside agriculture had some land at their disposal in the first half of the nineteenth century (although it has to be remarked that this group was already a minority by 1755). So those mainly active outside agriculture contributed less to the labour input.

4. Because of the slight shift in production from livestock to arable farming winter-unemployment under male labourers began to increase, being especially high in the period 1820-1840, but not disappearing completely in the next decades.

5. The increase in population resulted presumably in a small rise in the share of juveniles below 14 year in the population, a group that in the Groningen clay region to a very limited extent was involved in economic labour, even in agriculture. Only around the age of 14 children of labourers started to work for wage significantly (Paping 2005), and the young children of farmers below 14 will also have contributed to a limited extent to the farm work.

6. Due to rising labour opportunities already mentioned, unskilled labourers increasingly worked outside agriculture in the first half of the nineteenth century. Wage work directly or indirectly (dike maintenance) related to agriculture, however, remained the by far most important source of income for the large majority of unskilled Groningen labourers.

Graph 6: Real agricultural production per inhabitant, 1770-1862



Of course in graph 6 the difference between the more optimistic labour and capital income estimate and the much more pessimistic estimate based upon the farm accounts shows up

again. Though even the optimistic real labour and capital income series suggests stagnation of agricultural production per inhabitant, while the farm accounts indicate a significant fall in agricultural production per head. Table 5 show that all indicators show decreases in agricultural production per head of the population for the period 1817-1862

Table 5: estimated annual trend growth of real agricultural production per head of the population, using different indicators.

| | 1770-1860 | 1817-1862 |
|---------------------------|-----------|-----------|
| Production statistics | - | -0.12% |
| Farm accounts series | -0,35% | -0.56% |
| Labour and capital income | +0,01% | -0.28% |

In conclusion, these findings indicate that for every inhabitant in the Groningen clay region there was at best on average just as much agricultural products available around 1860 as there was around 1770, but presumably less. For the period from 1817 onwards to 1862 a fall in available agricultural production per head is without doubt. In other words, people had less to eat in this period of population growth, precisely because of this population growth that without substantial technological innovation resulted in decreasing marginal returns of labour in agriculture.

The story, however, is a little more complicated if we take exports into account. The Groningen clay region was an important exporter of agricultural products. This export directed itself not only to the city of Groningen (nearly every kind of product), but also to Holland (especially cows, but also butter, grain, groats made from barley and oil) and even to Great-Britain (oats, oil-seed, groats, butter, sheep and cows).

The money earned by exporting agricultural products was used in several ways. The most important ones are:

1. To pay rents to landlords living outside the region (a burden that diminished considerably due to the improvement of property right and the fixed rents in a period of increasing land prices), and partly also to pay interest to lenders outside the Groningen clay region. The majority of this money went to the city of Groningen, where the higher middle class and the elite had a considerable financial interest in the Groningen clay region.
2. To pay taxes, that were largely spent outside the region, as there were not much civil servants living in the clay region, being concentrated in the city of Groningen, and later on in Holland, where the Dutch government spent a lot of money on the army (war and quarrels with Belgium 1830-1839 and colonial wars) and on the king, and where the Groningen clay region did not see much for in return. Belgium, for instance, was also an important customer of Groningen products, and there were not much direct relations with the colonial empire.

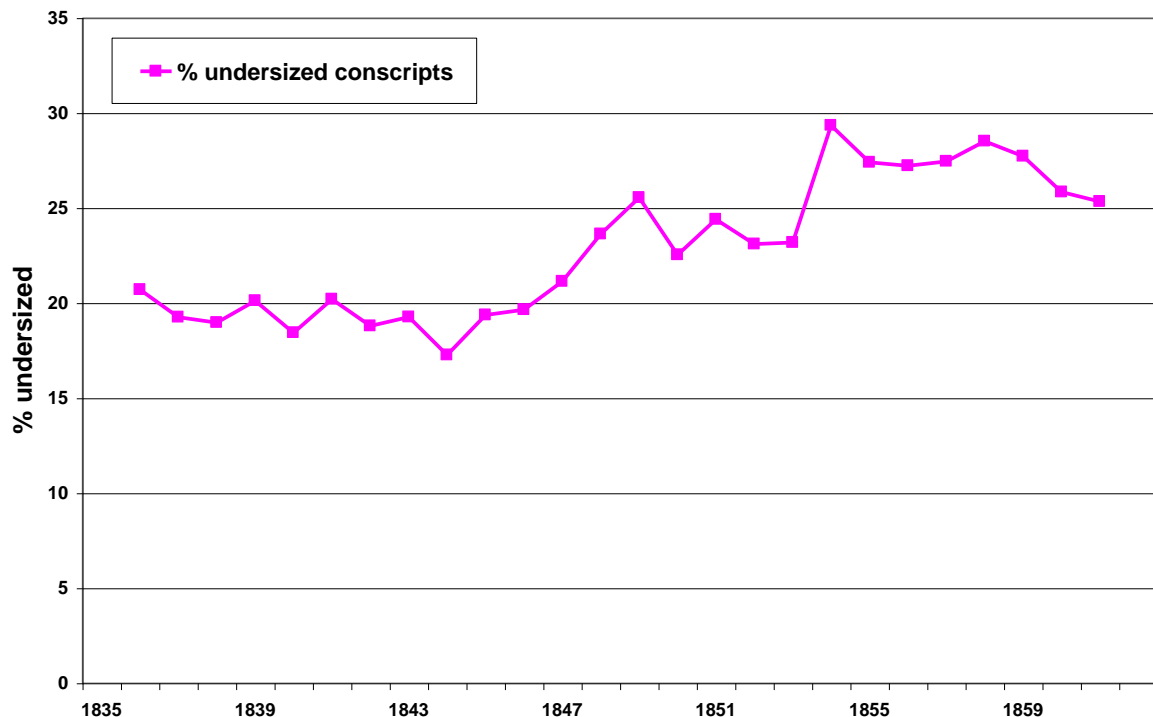
3. To buy luxury colonial goods (sugar, spices, coffee, tea etc) and to import all kind of industrial goods, especially textiles from Germany and later on England were of great importance. Though also a lot of specialised industrial goods and sometimes services came from the nearby city of Groningen.

4. To buy primary goods like wood (from the Baltic) and rye. The production of rye was too low in the Groningen clay region, as the farmers specialized in more rewarding agricultural products like wheat and oil-seed, so part of the rye needed to bake bread was imported through the grain market of Groningen, presumably originally mainly coming from nearby Drenthe and the Groningen peat districts.

There are no indications that the export of agricultural products actually diminished in the period 1770-1860, sooner the opposite might have taken place. From 1825 onwards, the terms of trade developed favourably for the Groningen clay region, due to the relative rise in agricultural (export) prices, compared to industrial (import) prices (Paping 1995a, p. 223). However, in the period before 1825 agricultural export prices even lagged behind, as the prices of industrial and other (colonial) import goods were increasing to a very large extent in the politically turbulent French period stretching from 1789 to 1815. It has to be remarked that these price developments did not show any sign of an increase in industrial productivity related to the so-called 'Industrial Revolution'. The price of linen, for instance increased from 44-52 cents a metre in the period 1770-1776, to 72-80 cents in the period 1789-1797, to fall to slightly above 60 cents in the years 1810-1817 (Paping 1995a, p. 376). Until 1825 the size of agricultural exports had to increase relatively to make up for the slightly negative development of the terms of trade, to still make it possible to pay for the necessary imports. If there was a rise in agricultural production per capita in the Groningen clay region, it presumably was exported. Most standard-of-living indicators (food consumption per head, real wages and real national incomes) show a long dip in the period 1795-1817, although there were also strong fluctuations from year to year (Paping 1995a, p. 204, 206, 213, 222, 245, 258).

The period after 1825 was both characterized by a very favourable development of the terms of trade and a falling agricultural production per capita. Between 1825 and 1860 the price level of export products for the Groningen clay region nearly doubled, while the price level of import goods diminished slightly (especially the price of linen/cotton textiles and iron were fell enormously). However, it were the shrinking group of already rich farmers who took the most benefit of this development. They were able to live a luxury life consuming large amounts of imported goods, and at the same time accumulate wealth, paying of their debts and buying also the ownership of the land, for which they already had the user right. Presumably this increasingly luxury life-style and also the capital transfer to outside the Groningen clay region just mentioned, must have stimulated the incentive to export agricultural goods. Most of the farmers households must have been well-feed the whole period under study. However, as the share of the farmers was decreasing, the social groups of inhabitants that were fed less well was increasing, a factor that also diminished per capita food consumption and released agricultural products for export.

Graph 7: Share of undersized 18 year old conscripts from the Groningen clay region, measured 1836-1861



For the increasing group of labourers real wages were stagnating during the whole period, but they were nevertheless also inclined to consume more industrial goods from 1825 onwards, as they became cheaper and so more attractive in this period. Taking into account the price level of houses and the price development of building material the quality of houses of labourers and middle classes (so excluding farms) rose for instance enormously (Paping 1995a, p. 266). The falling biological standard of living in the Groningen clay region is clearly shown in graph 7. Groningen people ate less, partly because there was less food available in the Groningen countryside, but also partly because they rather seemed to have spend less on food and more on (cheaper) imported products. Such decisions provoked by price incentives will have made it possible for the Groningen clay region to export an increasing part of the stagnating agricultural production from 1825 onwards, to supply the growing population elsewhere in Europe (for instance in Great Britain) with more food.

9. Concluding remarks

In the capitalistic agricultural Groningen clay region population growth resulted in a stagnating or even falling agricultural production per capita, despite all kinds of innovations of farmers to make use of the abundantly available cheap labour from the end of the eighteenth century to about 1860. In the same time local consumption of agricultural products per capita stagnated or even deteriorated. Improving terms of trade, took care that from 1825 real regional income per capita was increasing, though this improvement was not spent on an

increase in the consumption of foodstuffs, but on imported (luxury) industrial goods. It can be concluded that higher food prices from 1830 were indeed an important incentive to attract more agricultural products to the world market, where they were needed to satisfy the increasing demand in industrializing and urbanizing countries outside the Netherlands from the end of the eighteenth century onwards.

The figures for Groningen, a region characterized by very capitalistic, modern, non-traditional and innovative farmers, suggest that productivity increases in agriculture in this first phase of European industrialisation, urbanisation, modernisation and population growth might indeed seriously have lagged behind compared to the developments in the industry and service sectors. Consequently, higher real incomes were often accompanied by falling standards-of-living concerning food-intake in large parts of the western world in the first half of the nineteenth century. Although this is suggested otherwise in the literature (Komlos) this is no paradox, but actually the consequence of diverging developments in industry (and services) on the one hand, and agriculture and the resulting different price developments. It was only with the technological agricultural breakthroughs of second half of the nineteenth century (mechanization, fertilizers) and the opening up of large stretches of land outside Western-Europe (America, Argentina, the European colonies e.a.) that had not been (efficiently) cultivated before, that Western-Europe world really completely escaped from Malthus dismal predictions.

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